TABLE 1.—*Solar radiation intensities during February, 1917*—Continued.

Santa Fe, N. Mex.

Date.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass. 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Feb. 1	.....	.....	1.64	1.57	1.49	1.42	1.36	.....	.....	.....
5	.....	.....	1.47	.....	.....	1.32	1.27	.....	.....	.....
8	.....	1.55	1.50	1.44	1.38	1.26	.....	.....	.....	.....
9	.....	1.61	.....	.....	.....	1.36	1.29	.....	.....	.....
13	.....	.....	.....	1.44	1.37	1.30	1.24	.....	.....	.....
16	.....	.....	1.49	1.39	1.31	.....	.....	.....	.....	.....
Monthly means	.....	(1.58)	1.52	1.46	1.39	1.33	1.29	.....	.....	.....
Departure from 5-year normal	.....	±0.00	+0.05	+0.07	+0.08	+0.04	+0.04	.....	.....	.....
P. M.										
Feb. 8	.....	.....	1.46	1.41	1.35	.....	1.26	1.16	1.08	.....
Monthly means	.....	.....	(1.46)	(1.41)	(1.35)	.....	(1.26)	(1.16)	1.08)	.....

Table 2 shows very low vapor pressures at the above stations on the days when these high readings were obtained.

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	p.m.
1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*
Feb. 1	8.81	2.16	Feb. 2	0.20	0.46	Feb. 1	0.23	0.33	Feb. 1	1.19	1.02
2	1.02	0.86	8	1.96	0.53	2	0.23	0.53	5	1.60	2.62
3	0.51	0.97	9	0.48	0.71	8	1.78	1.24	8	2.16	2.26
5	0.66	0.58	10	0.48	0.71	10	1.78	1.78	9	2.06	2.16
6	1.12	1.78	17	3.81	1.37	15	3.45	3.15	13	2.36	3.63
10	0.71	0.97	20	1.02	1.32	16	3.15	3.99	16	1.78	2.36
12	0.81	0.64	21	2.26	1.45	23	0.97	1.37	.....	.....	.....
13	0.56	1.45	24	0.86	1.07	26	3.15	1.78	.....	.....	.....
17	3.63	4.17	27	0.86	1.24	.....	.....	.....	.....	.....	.....
.....	.....	.....	28	1.32	1.78	.....	.....	.....	.....	.....	.....

Table 3 shows about the normal amount of radiation for the month at Washington and Lincoln, and an excess of about 17 per cent at Madison.

TABLE 3.—*Daily totals and departures of solar and sky radiation during February, 1917.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals. Washington.	Madison.	Lincoln.	Departures from normal. Washington.	Madison.	Lincoln.	Excess or deficiency since first of month. Washington.	Madison.	Lincoln.
	calories.	*calories.*	*calories.*	*calories.*	*calories.*	*calories.*	*calories.*	*calories.*	*calories.*
Feb. 1	206	320	351	0	115	97	0	115	97
2	204	325	303	86	117	46	86	232	143
3	359	280	258	148	70	−2	234	302	141
4	296	270	211	83	57	−52	317	359	89
5	326	306	267	111	90	1	428	449	90
6	362	235	155	144	16	−115	572	465	−25
7	231	263	294	9	40	21	581	505	−4
8	144	336	280	−81	110	4	500	615	0
9	154	354	142	−74	125	−138	426	740	−138
10	373	359	336	142	126	53	568	866	−85
11	361	360	328	127	124	42	695	990	−43
12	332	271	227	94	32	−63	789	1,022	−106
13	340	177	193	99	−66	−100	888	956	−206
14	278	262	309	34	16	13	922	972	−193
15	28	115	231	−210	−134	−68	703	838	−261
16	149	320	328	−102	67	26	601	905	−235
17	309	347	341	55	91	36	656	996	−199
18	116	308	198	−141	49	−110	515	1,045	−309
19	99	85	298	−161	−178	−13	354	867	−322
20	67	394	342	−197	138	28	157	995	−294
Decade departure							−411	129	−209
21	245	220	371	−22	−49	54	135	946	−240
22	381	267	292	111	−6	−28	246	940	−268
23	142	311	368	−132	35	45	114	975	−223
24	270	402	306	−7	123	−20	107	1,098	−243
25	372	195	335	92	−87	7	199	1,011	−236
26	196	278	341	−88	−8	10	111	1,003	−226
27	182	409	355	−106	119	21	5	1,122	−205
28	26	378	335	−266	85	−2	−261	1,207	−207
Decade departure							−418	212	87
Excess or deficiency since first of year. (calories							−793	+2,085	−407
Excess or deficiency since first of year. (Per cent							−6.4	+17.3	−2.8

In Table 4 the high value of the solar constant obtained from the A. M. measurements of February 1 at Lincoln is probably due to the presence of local smoke during the morning, and its passing away before noon. Likewise, the low value of the solar constant obtained from the A. M. measurements of February 8 at Santa Fe is probably due to the effect of local smoke. It will be noted that in general the solar constant values obtained are slightly higher than Abbot's average value.

TABLE 4.—*Solar radiation intensities for zenithal sun reduced to mean solar distance of the earth, and approximate values of the solar constant.*

[Gram-calories per minute per square centimeter of normal surface.]

Station.	Date.	Radiation intensity. m = 1	m = 0	Solar constant.
	1917.	*calories.*	*calories.*	*calories.*
Washington, D. C.	Feb. 6, a. m. and p. m.	1.54	1.80	1.88
	10, a. m.	1.51	1.84	1.91
Madison, Wis.	Feb. 2, a. m.	1.62	1.82	1.88
	9, a. m.	1.71	1.92	1.98
	17, p. m.	1.63	1.85	1.95
	27, p. m.	1.65	1.88	1.95
Lincoln, Nebr.	Feb. 1, a. m.	1.86	2.06	2.12
	1, p. m.	1.75	1.95	2.01
	2, a. m.	1.75	1.98	2.04
	10, p. m.	1.64	1.81	1.89
Santa Fe, N. Mex.	Feb. 1, a. m.	1.75	1.92	1.99
	8, a. m.	1.57	1.70	1.78

Skylight polarization measurements made at Washington on four days when there was no snow on the ground give an average of 65 per cent, and a maximum of 69 per cent on the 10th. These are about average values for Washington for February.

ERRATUM.

In the MONTHLY WEATHER REVIEW for November, 1916, p. 615, column 2, the equation for computing the sun's hour angle from the meridian *should read*

$$\cos h = \frac{\sin a - \sin \phi \sin \delta}{\cos \phi \cos \delta}$$

This correction should also be made where this equation occurs in the reprint of the article, viz, at the bottom of page 6.

551.576 (74)

THE SMOKE CLOUD AND THE HIGH HAZE OF 1916.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, D. C., Mar. 27, 1917.]

Description of the smoke cloud.

During the last four or five days in July, 1916, a dense cloud of smoke overspread eastern New York and the New England States. Apparently it was first observed in northeastern New York on July 27, but its maximum effect appears to have been observed in northern New England on July 30. This day was described as "dark" at Gardiner and Eastport, Me., and Westboro, Mass., and as "yellow" at three Weather Bureau stations in Maine, four in New Hampshire, two in Vermont, and one each in Massachusetts, Rhode Island, and Connecticut.

During this same period smoke, mostly from forest fires, was recorded at many stations in Michigan, and haze or smoke, but usually haze, was recorded at a few stations

in Ohio, Kentucky, Indiana, Illinois, Wisconsin, Iowa, and Nebraska. It was not recorded in Tennessee, Missouri, Colorado, or Wyoming.

In western New York, in New Jersey, and in Pennsylvania smoke or haze was quite generally recorded on July 28–31; in Maryland, Virginia, West Virginia, North Carolina, and South Carolina on July 29–31; and in Georgia on August 1–3. South of Virginia the records generally read "haze."

The brilliant twilight colors of July 30–31, 1916.

Near the outer edge of the smoke cloud brilliant twilight colors, usually red, were recorded on July 30 or 31, at the following stations:

Westboro, Mass.; Providence, R. I.; Hartford and New Haven, Conn.; Ithaca and Binghamton, N. Y.; Plainfield, N. J.; Lewisburg, Pa.; Baltimore, Easton, and Fallston, Md.; Washington, D. C.; Richmond and University, Va.; Elkins and Piedmont, W. Va.; McConnelsville, Ohio; Lansing, Mich.; and Keokuk, Iowa.

Cause of the smoke cloud.

This smoke cloud undoubtedly came from forest fires in Ontario, Canada, respecting which the director of the Canadian Meteorological Service writes as follows:

Forest fires became rather prevalent in northern Ontario after July 20, and on July 29 and 30 a fire of unusual dimensions and fury swept over a tract of country about 60 miles square centered about lat. 48° 45′ N. and long. 81° W.

The smoke became very dense in the Canadian Maritime Provinces on the 30th, and that date is there spoken of as the "dark day." On the evening of that day I received a telegram from a judge at St. Andrews, New Brunswick, asking for an explanation of the extraordinary phenomenon. It appears probable to me that with the exceeding great intensity of this fire the smoke may have reached higher atmospheric levels than is usual in more moderate fires.

Observations of the high smoke or haze of July–August, 1916.

Outside of New England and eastern New York, where the smoke cloud was densest, a high haze of unusual character was quite generally observed, apparently drifting westward. Thus it was recorded at a few stations in Alabama, Mississippi, and Louisiana from July 31 to August 2; in Texas from July 30 to August 4; at Roswell, N. Mex., from August 2 to 4; in Arizona from August 4 to 7; and in southern California from August 2 to 9. The following extracts from observers' notes will make clear the character of this haze:

Madison, Wis., July 27–29.—Haze so thick it was possible to look at the sun an hour or more before sunset.

Lincoln, Nebr., July 26.—Pyrheliometric readings discontinued at 8:09 a. m. on account of haze. Only about 2/10 Cu. clouds, but sky a pale yellow in the direction of the sun. The haze was visible as a gray cloud bank around the horizon to a height of 30°. The remainder of the sky was of a grayish blue tint, with haze discernible as very light cirrus cloud forms.

Haze was also observed at Lincoln on the 27th, 28th, 29th, and 31st, and on August 2–4.

At the *Aerological station, Drexel, Nebr.*, about 50 miles northwest of Lincoln, no record of haze was made except the following on August 4: Very thin veil of cirrus haze visible at times in portions of sky from 11 a. m. to 7 p. m.

Highlands, N. J., July 30.—A dense haze rather than clouds.

Richmond, Va., July 31.—The elevated stratum of smoke continued throughout the entire day, and together with some A. Cu. clouds was sufficient to prevent a record of sunshine. The disk of the sun was faintly visible during a considerable portion of the day, but the light was not strong enough to cast a shadow.

Lexington, Ky.—Dense haze prevailed from p. m. of July 30 to a. m. of July 31, when it became light, and continued throughout the day. Except for its density, and its apparent extent to a great height, it was not remarkable. It was the only dense haze that occurred during 1916.

Special weight should be given the following notes which were made at *Raleigh, N. C.*, by Assistant Observer Thomas R. Brooks, who had observed the dense haze of June, 1912, at Mount Weather, Va., and states that he was impressed with the similarity in the appearance of this latter haze to that of the haze of 1912.

July 31.—The sky was overcast during the day by a heavy veil ranging in color from a bluish white near the zenith to a dull gray at the horizon. This was carefully examined to determine whether it consisted of cloud or haze. During the greater part of the day it was uniform throughout, exhibiting no irregularities of color or texture except the gradual and natural change from zenith to horizon. In the late afternoon, however, the sky near the sun became mottled in appearance and the vague outlines of clouds were seen within the immediate vicinity of the sun. The sun shone faintly all day and it was noticed that shadows were fringed with a reddish tint and that sunlight streaming into a darkened hallway was tinged with a reddish color.

Anniston, Ala.—Haze was recorded from July 31 to August 2. On the afternoon of the 31st the haze was light, with increasing upper clouds. Only the red rays penetrated the haze and clouds, and the sun was seen as a red disk.

Meridian, Miss., Aug. 1–2.—Cirrus haze caused the sunlight to be dim.

San Antonio, Tex., Aug. 3.—Dense haze; sun nearly obscured at sunset.

Abilene, Tex., Aug. 4.—Haze dense enough to practically obscure cirrus or cirro-stratus clouds.

Mount Wilson, Cal.—From notes kindly furnished by Mr. C. G. Abbot, director of the astrophysical observatory, Smithsonian Institution, it appears that the presence of cirrus clouds toward the end of July somewhat masked the effect of haze; but there is evidence of its presence at intervals after the 19th, probably increasing in density to about August 7, on which date the following note was made: "Sky streaked and fluted much like volcanic sky;" and on August 8, "Sky like yesterday; worse in morning, somewhat better in the afternoon." The notes indicate decreasing haziness until about August 29, after which date it was scarcely noticeable. The sky was generally described as *milky*, or *streaky* near the horizon in the direction of the sun.

A note on the decrease in solar radiation intensities at Washington, D. C., Madison, Wis., and Lincoln, Nebr., due to this haze, will be found in the REVIEW for July, 1916, 44:382; and a description of the remarkable haze observed at Roswell, N. Mex., on August 2–4, will be found in the REVIEW for October, 1916, 44:550.

Meteorological conditions accompanying the haze and smoke.

From July 27–31 an area of high pressure (No. VIII on Chart II, "Tracks of Centers of High Areas," MONTHLY WEATHER REVIEW, July, 1916) advanced from Quebec to the Maine coast, and thence southwestward to Alabama. During this period there was considerable cloudiness in the Atlantic Coast States, and especially along the New England coast; but the 29th was generally clear north of Virginia, and the 30th was clear from southern New England to Georgia. The winds were generally light and variable. From the 27th to the 30th clear weather with southerly winds and high temperatures prevailed over the Central States.

On August 1, from an area of high pressure central over the Great Lakes (No. I on Chart II, "Tracks of Centers of High Areas," this REVIEW, August, 1916) a ridge of high pressure extended southwestward into Texas. The extremity of this ridge became separated

from the main area, and persisted as a secondary HIGH, with a slow westerly drift, until it disappeared over Colorado on August 4.

From the above it will be seen that the smoke and haze that covered the Atlantic Coast States at the end of July, 1916, and also the haze that extended from Texas to California early in August, was first observed in an area of high pressure, where the seeing is usually good. The haze observed at about the same time in the Ohio and Mississippi valleys, and westward to Nebraska, occurred in connection with an unusually hot and dry period, which of itself would introduce great quantities of dust into the lower atmosphere.

"Twilight-cirrus haze."

While, as stated above, the high haze was scarcely noticeable during the daytime at Mount Wilson, Cal., after the end of August, 1916, a fine cirrus-like formation was observed there at sunrise by Assistant Astronomer Wendall P. Hoge, during the months of August, September, and October.[1] He describes it as "streaks of velvety clouds that gave one the impression of a canopy of color spread overhead far to the east." Mr. Ford A. Carpenter, meteorologist, Weather Bureau, also observed these cirrus-like formations at Mount Wilson on the morning of September 4. At Tucson, Ariz., Dean A. E. Douglass, of the University of Arizona, began observing this high haze on September 16, 1916.[2] He states that "This structure usually appears as a faint soft etching of large numbers of parallel lines." From cloud shadows cast on this haze layer after sunset he computed its height to be about 12 miles (19 kilometers).

Very similar to the above is Maurer's description of the high haze observed in the Alps from the middle of July to the middle of November, 1916.[3] The following is quoted from Nature (London) for December 28, 1916, **98**:328:

> This remarkable optical deterioration of the atmosphere was visible here (Zurich) until about the middle of November. The thin, cirrus-like layer could be seen on clear mornings just before sunrise at a height of about 14–15 km. above the earth's surface, according to our reckoning; that is to say, it was situated considerably above the usual cirrus region. It consisted of thin horizontal bands, extremely delicate and soft, which soon disappeared after sunrise. A curious fact was that no appreciable effect, either actinometric or photometric, was produced by this thin, mistlike layer. The impression made was that of a most delicate, cometlike veil of mist, yet not dimming the starlight. After sunrise absolutely nothing was to be seen of the phenomenon, in spite of the keenest observation through field-glasses of a weak magnifying power. * * *
>
> During the period of maximum visibility of the thin veil (twilight-cirrus), such a conspicuous layer was to be seen in the eastern sky, shortly before sunrise and at a height of 40°, that even an unskilled observer would have noticed it at once. The structure of the layer was often so regular and definite in its remarkable horizontal stratification that it looked as though an artist with a coarse brush had colored the whole eastern sky with long horizontal strokes not too neatly laid on.

Brilliant twilight colors during the latter part of 1916.

In addition to the observations of brilliant twilight colors on July 30–31, referred to above, brilliant twilights were quite generally recorded from Texas westward to southern California during the first week in August. Thus, at El Paso, Tex., the record reads:

> Light haze about 6 a. m. August 2, and continued until the forenoon of the 6th. During this period the sun's appearance at sunrise and sunset was remarkably red, and the twilight colors gorgeous.

Descriptions of the phenomena as observed at Mount Wilson, Cal., and Tucson, Ariz., have already been published in the MONTHLY WEATHER REVIEW for November, 1916, **44**: 625–627.

These brilliant twilight colors were observed at Los Angeles, Cal., until the end of November, 1916.

Astronomer W. P. Hoge writes, under date of March 31, 1917, that at Mount Wilson, Cal.:

> The phenomenon is still in evidence every clear morning, but with greatly reduced intensity. While not conspicuous it certainly still exists. The streamers [crepuscular rays] that were so noticeable at first are no longer visible, but the soft velvety canopy far to the east can still be faintly seen.

At Tucson, Dean A. E. Douglass, under date of March 9, 1917, writes that "The cirrus-like haze and the brilliant twilight glow of last autumn have by no means disappeared, although the latter has decreased in brilliancy."

In this connection it is of interest to note that in the Journal of the Royal Astronomical Society of Canada for February, 1917, **11**: 79, Mr. A. F. Hunter states that in Canada the sunsets, and especially the afterglows, have been unusually brilliant during the past few months.

Cause of the high haze and the brilliant twilight colors.

As already stated, the smoke cloud that covered New York and New England at the end of July, 1916, undoubtedly originated in the forest fires that prevailed in Ontario, Canada. It is not possible to determine the southern or western boundary of this cloud; but there is no reason for supposing that it was in any way connected with the high haze observed from Texas westward early in August. We certainly can not suppose it to have been the cause of the high cirrus-like haze observed in Arizona and southern California from August, 1916, to March, 1917; or to have produced the brilliant twilight colors that accompanied the haze. Rather, we must attribute these latter to the same cause that produced the brilliant twilights in Canada, and the high haze observed in Switzerland.

These phenomena have been attributed to a variety of causes, such as the gases arising from the great battle fields of Europe, cosmical dust, and volcanic dust. The similarity of the high haze of 1916 to that of 1912 has been here pointed out, and Prof. Riccò has called attention to the fact that Stromboli volcano was in violent eruption early in July, 1916.[4] Unfortunately, definite data relative to the violence of the eruption, and the height to which volcanic ash was thrown into the atmosphere, is lacking. At present, however, this eruption appears to be the most probable source of the high haze of 1916. The marked diminution in its intensity at the end of the year argues against its arising from the battle fields of Europe.

Assuming this eruption to be the source, then the cirrus-like haze is probably a thin layer of fine dust that was thrown to more than the average height by an unusually violent explosion, which dust, because of the fineness of its particles, falls more slowly than the denser lower cloud that was made up of coarser particles.

Since above about 14 kilometers the wind velocity from the east increases quite rapidly with altitude, the

[1] See this REVIEW, November, 1916, 44: 626.
[2] See this REVIEW, November, 1916, 44: 625.
[3] See also: *Maurer, J.* Zur atmosphärisch-optischen Störung des Sommers 1916. Meteorol. Ztschr., Nov. 1916, 33: 515–517.
Wolf, Max. Ueber die höchsten Dämmerungswolken., ibidem, p. 517–519.
Laska, V. Abnormale Dämmerungserscheinungen im Sommer 1916, ibidem, p. 520.—EDITOR.

[4] See this REVIEW, October, 1916, 44: 550.

finer dust cloud, with its accompanying brilliant twilight colors, might well be observed in the clear atmosphere of southern California some days in advance of the denser lower cloud, and, indeed, before the latter had been observed in States farther east.

It also seems fair to assume that this volcanic dust was at least in part the cause of the high haze observed over the South Atlantic States at the end of July; and it may have been a contributing cause of the brilliant twilight colors observed on July 30–31 in the eastern part of the United States.

FREE-AIR DATA IN THE HAWAIIAN ISLANDS, JULY, 1915.

By Col. WILMOT E. ELLIS, Coast Artillery Corps, U. S. Army.

[Dated: Fort Ruger, H. T., Jan. 23. MS. received Feb. 7, 1917.]

The title of this article suggests that the usual paraphernalia of sounding balloons, captive balloons, or standard kites with self-registering instruments were utilized in making our explorations, but such was not the case. Our exploring apparatus consisted of two "home-made" kites and of cast-iron projectiles fired from 12-inch sea-coast mortars. Although our experimental firings were conducted primarily with a view to obtaining ballistical information, we incidentally obtained considerable information of interest to the aerologist. The purpose of this article is to discuss the results obtained with special reference to aerology.

Explorations of the upper air within the Tropics have been very limited in number and in the extent of the territory covered. There has been none whatever in our insular possessions.[1] Systematic exploration work has been carried on at Batavia in the Dutch East Indies. The chief of the U. S. Weather Bureau in a letter to the commanding officer, Fort Ruger, under date of September 10, 1915, states:

> A typical pilot balloon observation made by Mr. Van Bemmelen, in charge of the observatory there [Batavia], shows the trade winds to be about 3 km. deep, with a velocity of 5 m. p. s. The anti-trades extend from 3 to 17 km., their velocity increasing gradually from 5 m. p. s. at 3 km. to 23 m. p. s. at 14 km. The upper trade winds extend from 17 to 18 km., and have low velocities like the surface trades. Between the 18- and 23-km. levels, a high westerly wind, velocity 10 to 15 m. p. s., was found. Above this level, to the highest level explored, easterly winds again prevailed, reaching velocities of 40 m. p. s. in the vicinity of the 30-km. level.

In the Hawaiian Islands, the prevailing winds are the northeast trades and have a temperature of about 70°F. The relative humidity averages 65 per cent. These conditions are greatly modified by mountains and local convection currents. There are two principal ranges on the island of Oahu. The Koolau extends along the northeastern or windward side. The Waianae range is on the southwestern side. Both ranges are covered with dense vegetation. The elevation averages between 2,000 and 3,000 feet, the highest altitude being about 4,000 feet. Between the two ranges is an elevated tableland. The moisture carried by the trades is largely precipitated upon these mountains, but they are not high enough to keep the wind from sweeping over them and through the deep valleys on the leeward side. The trades are at least 4,000 feet deep, and—as will be shown later—our mortar firings indicate that they are about the same depth as the southeast trades at Batavia—approximately 10,000 feet. The trades are generally interrupted by "konas" or southerly gales, from November to the latter part of March. The konas are damp and blustering winds, warmer and more humid than the trades. As might be expected, the winds on the leeward side are—during the prevalence of the trades—more or less capricious. There is considerable diversity in wind directions well above the surface of the earth. True cirrus clouds, whose altitude ranges about 26,000 feet, are not common; but, when observed, they generally indicate a movement with an anti-trade component.

In our system of sea-coast mortar firing, we use a series of imaginary zones described about the mortar battery as a center. These zones are numbered from 1 to 9 outward, zone 1 being nearest the battery. Projectiles of three different weights are used, and the powder charge varies for each zone. The angles of elevation for each zone run from 45° to 65°, the former elevation giving the maximum range and the minimum height of trajectory, and the latter the minimum range and the maximum height of trajectory. Each zone overlaps its neighbor for a distance varying from about 500 yards to about 1,000 yards, so that a change in ammunition can always be smoothly made in firing at a target whose course involves a change in zone. Our plotting board gives us the direction and distance of the target from the battery. Range tables calculated by our ballisticians furnish us with elevations corresponding to ranges, and the drift of the projectile for the various elevations. The drift of the projectile is always to the right, increasing with the elevation. The drift is considerable, and must be allowed for in laying the mortar in direction. For example—the drift at an elevation of 65° in the 9th zone is about 1,450 yards for a time of flight of 75 seconds. In training for direction, the mortar is laid in azimuth, azimuths being reckoned from the south point clockwise through the west point. When a series of shots are fired at a fixed point, using the same elevation, azimuth, and ammunition, it rarely happens that any shot falls within a hundred yards or so of the point, owing principally to variations in the muzzle velocity and the unknown aerological conditions that the projectile encounters in its flight.

Col. Rafferty's experiments, July, 1915, at Oahu.

In February, 1915, Col. W. C. Rafferty, Coast Artillery Corps, commander of the coast defenses of Oahu (located in and near Honolulu) obtained authority from the War Department to fire a series of 74 shots from the 12-inch mortars. The purpose of the firing was:

1. To determine the drift of the 700-pound projectile in the ninth zone, and the 824-pound projectile in the eighth zone;
2. To determine the law which governs the deviation due to wind;
3. To discover any other information relating to mortar firing which may be useful to the service.

The shots were distributed between two batteries, Battery Harlow at Fort Ruger near Diamond Head Crater, and Battery Hasbrouck at Fort Kamehameha adjoining Pearl Harbor. These batteries are about 11 miles apart, the former being about 5½ miles east of Honolulu Harbor, and the latter about the same distance west thereof.

[1] See, however, *O. L. Fassig:* Kite flying in the Tropics. MONTHLY WEATHER REVIEW, Dec. 1903, 31:582–587. 5 figs., for an account of upper-air observations by means of kites during the expedition to the Bahamas in 1903, under the auspices of the Geographical Society of Baltimore.—EDITOR.